Differences In Web-Spider Communities Associated With Three Old-Field Communities In Southwest Ohio[1]

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ABSTRACT. **Plant architecture is known to have an impact on web-building spider communities. Web-spider abundance and distribution were monitored in September 1986 and 1987 on three types of plots with distinct plant communities. Differences were seen in spider abundance, family composition, and dispersion patterns between spider communities in control plots of old-field vegetation and plots treated with fertilizer or sludge. These differences were apparently related to changes in plant species composition, height, and density associated with nutrient enrichment. Differences in family representation and overall spider abundance were seen in the fertilizer and sludge plots as a result of decreases in plant density and increases in plant height. Spiders in fertilizer and sludge plots were distributed in a clumped pattern; spiders in control plots were distributed either uniformly or randomly. Low web site availability because of low plant density in nutrient enriched plots and high plant density in control plots was most likely responsible for these dispersion patterns.**

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INTRODUCTION

Many investigations have revealed relationships between plant communities and their associated spider fauna (Bultman et al. 1982, Duffey 1962, Fraser and Frankie 1986, Turnbull 1960). These studies have shown that architectural features of vegetation, prey availability, and microclimatic conditions all are important in determining the abundance and distribution of spiders (Almquist 1973, Duffey 1962, Fraser and Frankie 1986, Greenstone 1984, Hatley and MacMahon 1980, Robinson 1981, Rypstra 1986). The degree to which each of these factors, which are not independent, affects the spider community composition depends on the particular features of the habitat.

Understanding the factors that determine spider community structure could help humans to use spiders more effectively for biological control of insects. Riechert and Lockley (1983) suggested that, although populations of one spider species are not effective biological control agents, spider communities might be able to control insect pests. Different plant communities may support spider communities which differ with respect to their potential for insect control.

The modification of plant communities should cause corresponding changes in their associated spider communities. Early studies of the relationship between spider communities and plant communities revealed that the ecological succession of spiders (changes in species diversity and population density) corresponds to plant succession (Dowdy 1950, Lowrie 1948). More recently, Bultman et al. (1982) showed that changes in the composition of cursorial spider communities accompany

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changes in leaf litter structure associated with the different plant communities that occur along a successional gradient. Since different vegetation architectures provide different degrees of web support (Olive 1980), web-building spider communities would be expected to be influenced by vegetational alterations. The present study examined the influences of plant communities altered by fertilizer and sludge on their associated spider communities. The objective of this study was to determine how differences in vegetation structure influenced the web-building spider community in terms of abundance, family composition and dispersion.

MATERIALS AND METHODS

STUDY AREA AND BACKGROUND. To examine the differences in spider communities associated with different vegetation types, this study made use of a larger project conducted by G. W. Barrett at the Miami University Ecology Research Center near Oxford, Ohio. This 10-year (1977-1987) project investigated the effects of nutrient enrichment (fertilizer and sludge) on old-field ecosystems. The basic design of this project involved dividing an old-field community into eight 0.1-ha (approx. 30 × 30 m) plots enclosed with steel fences. This community was originally planted with winter wheat, *Triticum aestivum*, and then allowed to undergo secondary succession. Plots were randomly assigned to be treated annually with fertilizer (three plots), sewage sludge (three plots), or left as controls (two plots). Three distinct plant communities developed within plots of the different treatments. Carson et al. (1987), Hyder and Barrett (1986), and Maly and Barrett (1984) can be examined for more details of this work and causes of plant community differences in the three treatments.

SPIDER SAMPLING. Data were collected from 26 to 29 September 1986 and from 26 to 27 September 1987. Each plot (30 × 30 m) was subdivided into 36 quadrats (5 × 5 m). Each quadrat was assigned a two-digit number, and then five quadrats were randomly selected (using a random numbers table) for each treatment type. Thus, a total of 15 quadrats were used each year.

Spiders were located by a thorough visual search of each quadrat until every spider was found. Family and distance to nearest neighbor (of any family) were recorded for each spider. The dispersion index J was calculated according to Poole (1974): $J = \bar{d}/d$; $d = 1/2N^{0.5}$, where N is the density of spiders; $\bar{d} = \Sigma d_i/n$, where d_i is the nearest neighbor distance measured for each individual and n is the total number of individuals.

PLANT SAMPLING. Vegetation was sampled in the same set of 15 quadrats on the same days mentioned for the spider sampling. A circular quadrat (0.25 m^2) was placed in the center of each quadrat. Smaller areas were used for plant sampling because of the time involved in collecting plant data with specimens of high vegetation density. Total number of plants in the circular quadrat was recorded. Plant species and stem height were recorded for each individual.

RESULTS

PLANT SPECIES COMPOSITION. The plant species that characterized the plots differed among all three treatments within a year (Fig. 1). Although the control plots differed only slightly between years, the vegetation in the fertilizer and sludge plots changed dramatically from 1986 to 1987. In 1986, each treatment type was dominated by one plant species: *Ambrosia trifida* for fertilizer, *Ambrosia artemisiifolia* for sludge, and *Solidago canadensis* for the control. In 1987, the fertilizer plots were composed of 50% *Ambrosia trifrida* and 50% *Setaria faberii;* the sludge plots were 100% *S. faberii.*

PHYSICAL CHARACTERISTICS OF PLANT COMMUNITIES. The mean height of the vegetation (all species) in 1986 was significantly different between treatments (analysis of variance [ANOVA], $F = 72.78$, $P < 0.0001$, Duncan and Tukey multiple range tests $P < 0.05$) (Table 1). The vegetation heights of the fertilizer and sludge treated plots were considerably higher than the control in 1986. In 1987, the grass *S. faberii* made up a major portion of the fertilizer and sludge plots. As a result, the average height of the vegetation was much less than in 1986 for these treatments. Because of the big differences in plant species composition, the overall structure of the vegetation was very different between years. This difference resulted from *S. faberii* being a thin grass which grows in dense clumps and bends over to shade surrounding areas, whereas the *Ambrosia* species consist of a single thick stalk and are sturdier and much taller than *S. faberii.*

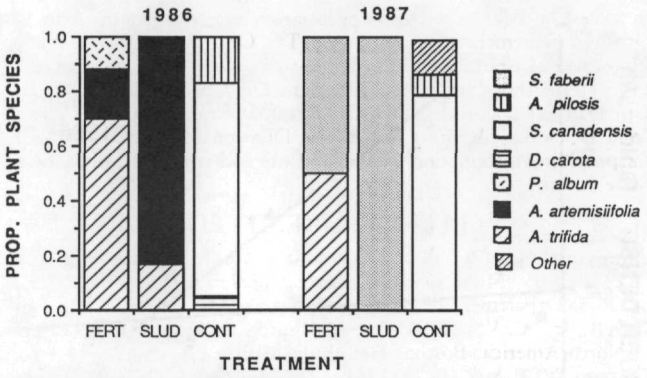

FIGURE 1. Relative proportions of plant species in fertilizer (FERT), sludge (SLUD) and control (CONT) plots in 1986 and 1987.

The density of the vegetation also differed among treatments in 1986 (Table 1), with the control plots having the highest number of plants per m^2. For 1987, the density measure was also affected by the grass *S. faberii.* The vegetation densities in the fertilizer and sludge plots in 1987 were low in comparison to the 1986 data. This was probably because of the fact that a grass clump consists of individuals which bend over and spread out. Therefore, it actually occupies more space by covering more ground area than an individual of *Ambrosia* sp. or *Solidago canadensis* and potentially provides more substrate for spider web support. The density of individuals within a grass clump (Table 1) was similar between fertilizer and sludge plots in 1987. The change in the plant communities betwen 1986 and 1987 allowed a comparison of the associated spider communities betweeen years as well as between treatments.

SPIDER DENSITY. The density of spiders in the plots for all treatments showed a negative relationship

TABLE 1

Physical characteristics of plants in fertilizer, sludge and control treatments.

	Mean stem height ± SD (m)		Density (plants/m^2)	
	1986	1987	1986	1987
Treatment				
Fertilizer	2.44 ± 0.88	1.47 ± 1.02*	27.2	8.0(137.6)**
Sludge	1.56 ± 0.71	0.40 ± 0.09*	52.8	4.0(167.2)**
Control	0.96 ± 0.31	0.98 ± 0.30	65.6	82.4

*Height of *Setaria* grass is height of tallest part of a clump to ground; not individual height since most individuals were bent over.

**Numbers in parentheses are densities of individuals within a grass clump.

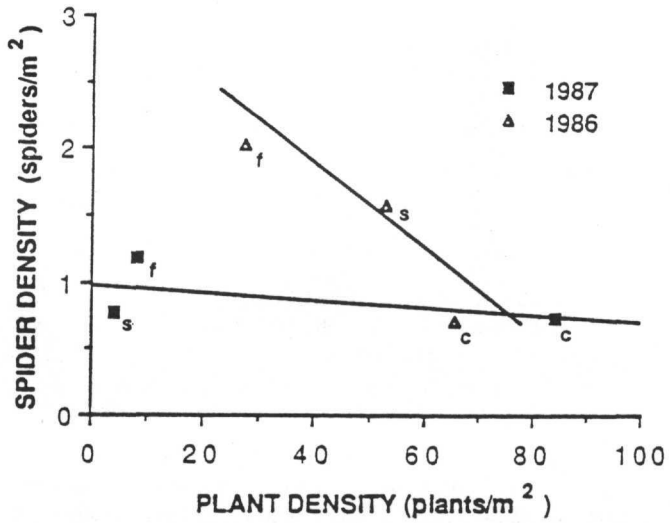

FIGURE 2. Linear regressions of spider density on plant density for the three treatments in 1986 and 1987. f, fertilizer; s, sludge; c, control.

with plant density in 1986 (Fig. 2). Although this relationship was not statistically significant ($F = 6.27$, $P = 0.24$), it was stronger than the 1987 data ($F = 0.365$, $P = 0.654$) probably resulting from the problems with measuring plant density mentioned above. In both years, the highest density of spiders was found in the fertilizer plots and the lowest in the control.

SPIDER SPACING AND DISPERSION. In 1986, mean nearest neighbor distance (NND) for spiders in the control plots was significantly different from fertilizer and sludge (Fig. 3, DTMRT, $P < 0.05$); however, mean NND between fertilizer and sludge plots was not different (Fig. 3, DTMRT, $P > 0.05$). In 1987, mean NND was significantly different among all three treatments (Fig. 3, DTMRT, $P < 0.05$). The only significant difference in NND between years was in the sludge plots. Spiders in fertilizer and sludge plots were distributed in a clumped fashion in both years (Table 2). The pattern of dispersion for spiders on control plots was random in 1986 and uniform in 1987 (Table 2).

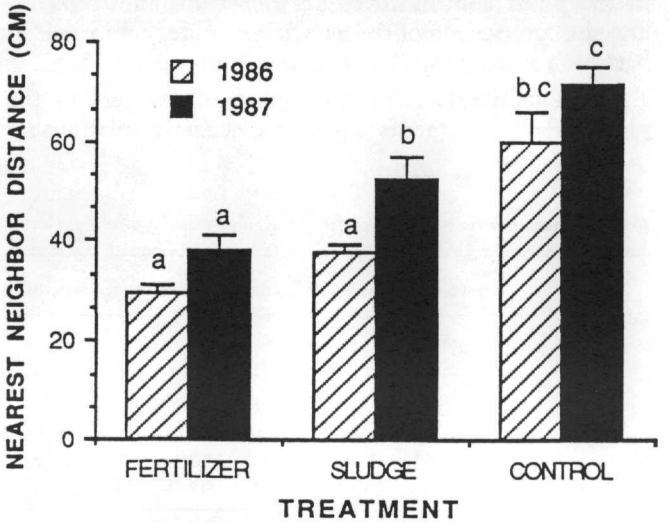

FIGURE 3. Mean nearest neighbor distance for spiders in fertilizer, sludge and control plots in 1986 and 1987. Bars are standard errors of the mean. Different letters indicate significantly different means according to Duncan and Tukey's multiple range tests ($P < 0.05$).

TABLE 2

Dispersion of spiders in fertilizer, sludge, and control treatments.

	1986	1987
	J value (Dispersion pattern)	*J* value (Dispersion pattern)
Treatment		
Fertilizer	0.85 (clumped)	0.84 (clumped)
Sludge	0.94 (clumped)	0.91 (clumped)
Control	1.01 (random)	1.22 (uniform)

SPIDER ABUNDANCE AND FAMILY COMPOSITION. The overall abundance of spiders (all plots pooled) was higher in 1986 (537) than in 1987 (333). When comparing the three treatments, the relative proportions of spiders in different families were significantly different (3×4 contingency table, $X^2 = 420.2$, $P < 0.0001$, Table 3) in 1986. However, the relative numbers of spiders in different families in sludge plots were not different from fertilizer plots in this year (2×4 contingency table, $X^2 = 2.6$, NS, Table 3). This indicates that the fertilizer and sludge plots were different from control plots but not from each other in 1986. The 1987 data indicate significant differences in relative numbers of spiders in different families for both the fertilizer-sludge-control (3×4 contingency table, $X^2 = 252.3$, $P < .0001$) and fertilizer-sludge (2×4 contingency table, $X^2 = 7.82$, $P < .05$) comparisons (Table 3). The control plots for both years were composed almost entirely of orb-web weaving araneids. Approximately 80-90% of these were *Argiope aurantia* and *Argiope trifasciata*. The most conspicuous difference between years was the abundance of theridiids in 1986 in the fertilizer and sludge plots and their virtual absence from these plots in 1987.

DISCUSSION

Changes in plant species composition and vegetation architecture associated with nutrient enrichment resulted in alterations of the web-spider communities in terms of their family composition, abundance, and spacing patterns. Araneids, although abundant in control plots (old-field vegetation), were absent from the fertilizer and sludge plots in 1986. This most likely resulted from the increase in plant height and decrease in plant density. The low density of plants in the fertilizer and sludge plots probably prevented the large orb-weaving spiders from occupying these areas since they require a considerable number of web attachment sites (Olive 1980, Uetz et al. 1978).

Although specific horizontal components of the vegetation were not measured, the control plots most likely offered more horizontal vegetational features than the other plots. This was because high plant densities in control plots caused the long lateral branches to overlap, whereas in the nutrient enriched plots, the plants were widely spaced and stalk-like with non-overlapping branches. The horizontal nature of the vegetation in control plots may have been preferred by the araneids. Fraser and Frankie (1986) and Robinson (1981) found that different spider species prefer different relative amounts of horizontal vs. vertical architectural features

TABLE 3

Numbers of spiders in different families for fertilizer, sludge, and control treatments in 1986 and 1987.

	Spider Family									
	Araneidae		Linyphiidae		Theridiidae		Agelenidae		Total	
	1986	1987	1986	1987	1986	1987	1986	1987	1986	1987
Treatment										
Fertilizer	9	8	83	138	160	0	0	1	252	147
Sludge	11	12	53	81	133	2	0	0	197	95
Control	88	90	0	1	0	0	0	0	88	91
Total	108	110	136	220	293	2	0	1	537	333

for web construction. Changes in vegetational architecture associated with the large changes in plant species composition in the fertilizer and sludge plots from 1986 to 1987 may have been one factor in causing the elimination of theridiids from these plots in 1987.

Duffey (1962) and Fraser and Frankie (1986) showed that plant structural diversity provides areas with different microhabitats which greatly influence spiders found in these areas. The tall *Ambrosia* species (abundant in fertilizer and sludge plots in 1986) produced more shade than the shorter vegetation found in the control plots. *Argiope aurantia* and *Argiope trifasciata* are typically found in open-field habitats and exposed to direct sunlight (Olive 1980); therefore, the shady habitat in the fertilizer and sludge plots may not have been suitable to these spiders. Additionally, it is possible that there were insect availability differences between plots of different vegetation types influencing spider presence. Although no conclusive insect data were collected in the present study, Sedlacek et al. (1988) found significantly higher homopteran population densities in nutrient-enriched plots compared to control plots in this study area in 1978.

Dispersion patterns of the spider communities in the three plot types were affected by the differences in vegetation density, as well as particular web architectures of spider families. The spiders in fertilizer and sludge plots were almost all linyphiids and theridiids which usually build small sheet or tangle type webs which therefore do not span large spaces as do many araneids (Gertsch 1979). The clumped distributions and small nearest neighbor distances of spiders in these plots were the result of the tendency for small groups of spiders to aggregate around the bases of the ragweed (*Ambrosia*) plants or grass (*Setaria*) clumps. The low density of plants in the fertilizer and sludge plots resulted in low availability of web sites which probably caused these spiders to aggregate around an individual plant. Higher plant density in control plots provided araneids with a greater number of potential web sites, therefore they could space themselves in a uniform or random fashion. In addition, the uniform spacing pattern seen in the control plots in 1987 may indicate the presence of territoriality among the spiders there.

Variation in microhabitats associated with changing plant structure in terms of physical architecture (and possibly related microclimatic factors and prey resources) affected the resident spider populations. Modification of vegetation structure in the fertilizer and sludge plots corresponded to differences in spider family representation as well as an increase in overall spider abundance. These findings may be significant with regard to Riechert and Lockley's (1983) contention that spider communities have a greater impact on insect abundance than single species populations. Shifts in spider community structure associated with nutrient enriched habitats could have important effects on insect populations. Biologists interested in using spiders as control agents may be able to control spider community composition by manipulating vegetation structure.

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